Mathematical Attitudes, Beliefs and Achievement in Primary Pre-service Mathematics Teacher Education

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This paper reports on a study focused upon 83 pre-service primary teachers in their first mathematics pedagogy subject at the University of Western Sydney. They completed three surveys: an achievement test of the mathematics they would be expected to teach; a survey of their beliefs about mathematics, mathematics teaching and mathematics learning; and a survey of their attitudes towards mathematics. The experiences and beliefs of pre-service teachers influence the formation of attitudes and these, in turn, influence their classroom practices and beliefs. These beliefs, attitudes and practices may sometimes be at variance with the main direction of their tertiary teaching methods courses. Thus, it is crucial in assisting pre-service teachers to understand their own beliefs, attitudes and practices, and that these are made explicit and examined. This paper reports the data from the achievement test, belief survey and the attitude survey, and investigates the relationships between these data. The results from this study show some connections, although relatively weak, among the three constructs and lead us to speculate on possible reasons for these.

This paper builds on the authors' previously reported research on pre-service teachers' achievement in mathematics (Southwell & Penglase, 2005), relationships between pre-service teachers' beliefs about mathematics, its learning and teaching and their mathematical achievement (Perry, Way, Southwell, White, & Pattison, 2005), and relationships between pre-service teachers' attitudes about mathematics and its teaching and their mathematical achievement (Southwell, White, Way, & Perry, 2006), and seeks to consolidate these findings into a coherent whole that explores pre-service teachers' beliefs, attitudes and achievement together. As such, it extends the previous reports by considering the data as a whole rather than as separate pairings. The paper seeks to shed light on the following research questions:

1. What, if any, are the relationships between the espoused beliefs and attitudes of pre-service teachers to mathematics and its learning and teaching and their achievement on a basic mathematics test set at junior high school level?
2. How successful are the instruments used to measure attitudes, beliefs and achievement in this study as indicators of the needs of pre-service teachers that might be met by mathematics pedagogy units in their teacher education courses?

Theoretical Framework

Beliefs and Attitudes

The research literature on beliefs reveals an area of considerable complexity with a lack of a common definition (McLeod & McLeod, 2002), that results in disagreement over whether beliefs are expressions of knowledge or opinion and whether beliefs belong to the cognitive or to the affective domain (Schuck & Grootenboer, 2004). Thus, a researcher who wishes to study beliefs has a duty to readers to clearly position the research within the range of available options. In this current study, beliefs are seen as what participants provided as suitable responses to open 'I believe' statements. The response is what the participant regards as true at that specific context and time (Ajzen & Fishbein, 1980).

The nature of the relationship between beliefs and behaviour is important in deciding if it is better to concentrate upon the behaviour, the beliefs, or both in order to improve behaviour. Ajzen and Fishbein (1980) reported beliefs influence behaviour and early research generally accepted that beliefs influenced behaviour in spite of a number of studies that reported inconsistencies. Argyris and Schon (1974, 1989) argued that the inconsistency was a result of people having a number of differing collections of beliefs. Theories of action were based upon collections of beliefs that influenced behaviour whereas espoused theories were based on collections of espoused beliefs. The two theories could contain considerable overlap of beliefs.

The inconsistencies might also be the result of behaviour influencing beliefs (Guskey, 1986), or as Cobb, Wood and Yackel (1990) claimed, the relationship is not linearly causal in either direction. As Beswick (2005) confirmed, beliefs and action develop together and influence each other because they are dialectically related. The context associated with beliefs is important (Pajares, 1992). Researchers argued that context is operational in the development and enactment of beliefs (Ajzen & Fishbein, 1980; Hoyles, 1992). As differing contexts may elicit different beliefs, consistency cannot be expected when beliefs and behaviour are measured if the contexts are not closely matched.

Attitudes are generally regarded as having been learnt. They predispose an individual to action that has some degree of consistency and can be evaluated as either negative or positive (Fishbein & Ajzen, 1975). They are linked to beliefs and for each belief an individual would have a corresponding attitude. Attitudes have been linked to action and can be categorised according to their focus. Thus, behavioural attitudes indicate a person's judgment of performing the behaviour as good or bad or that the person was in favour of or against performing the behaviour. Clearly, other things being equal, the more favourable a person's attitude is toward a behaviour, the more likely the person would intend to perform that behaviour. A dialectical relationship appears true for attitude and behaviour. Using structural equation modelling, Reynolds and Walberg (1992) found a causal influence of achievement upon attitude, whereas Imai's (1993) study presented findings which supported the opposite. Thus, there seems to be evidence of a two-way relationship between attitudes toward mathematics and achievement. When these relationships involve pre-service teachers' beliefs, attitudes and mathematical performance, the question arises: Where should tertiary mathematics educators devote their efforts?

Teacher Beliefs, Attitudes and Academic Achievement

How do the dialectical relationships between beliefs, attitudes and behaviour influence pre-service primary teachers and their mathematics? It appears the influence starts early with Stipek (1984) noting that, as early as Grade 2, students begin to appreciate that some children learn more quickly than others and that not everyone will be high achievers in school. Fennema and Sherman (1977, 1978) reported that middle school and high school students who achieved higher scores on tests of mathematical achievement perceived mathematics to be more useful than lower-achieving students. This is of concern if it also applies to later mathematics achievement as Rech, Hartzell and Stephens (1993) reported that the mathematical competency of American university students enrolled in elementary education majors was significantly lower than the established norms of the general population. This has also been noted in the context of the present study (Perry et al., 2005; Southwell & Penglase, 2005). Schoenfeld (1985) asserted that mathematical beliefs help constitute a mathematical 'world view'. Kloosterman and Gorman (1990) suggest that associated with the formation of these beliefs are attitudes that it makes little sense to put forth effort when it does not produce results that are considered desirable or good.

Of interest is whether tertiary educators are able to change the negative beliefs of the pre-service teachers towards mathematics and mathematics teaching. Recent studies testing the robustness of the existing beliefs of Australian pre-service teachers reported evidence of belief change, although the sizes of the samples were not large. Aldridge and Bobis (2001) tentatively reported a change in beliefs about mathematics towards a more utilitarian and problem solving perspective as a result of a university education program. Similarly Beswick and Dole (2001) also reported a change of mathematical beliefs of pre-service teachers undertaking an education degree subject.

Among South African pre-service teachers examined by Hobden (2001), personal beliefs about the nature of mathematics were found to be incompatible with the theoretical underpinning of the school curriculum. Several researchers (Amarto & Watson, 2003; Chick, 2002; Morris, 2001) have reported that pre-service teachers do not always have the conceptual understanding of the mathematics content they will be expected to teach. Schuck and Grootenboer (2004) stated research "on the beliefs of student teachers has found that prospective primary school teachers generally hold beliefs about mathematics that prevent them from teaching mathematics in ways that that empower children" (p. 58). This link between beliefs and classroom behaviour has been investigated with classroom teachers. Perry, Vistro-Yu, Howard, Wong and Fong (2002) found distinct differences between various primary teacher groups in their beliefs about mathematics and its learning, which led to speculation about the impact of these beliefs upon student achievement. Hannula, Kaasila, Laine, and

Pehkonen (2005) explored the structure of 269 Finnish pre-service teachers' views of mathematics and also their different belief profiles. The core of the student teachers' views consisted of three correlated beliefs: belief of one's own talent; belief of the difficulty of mathematics; and one's liking of mathematics. Concerning their view towards mathematics, students fell within three main categories: positive (43%); neutral (36%); and some negative (22%). Hannula et al. found that "some of the students with a negative view were seriously impaired as they felt that they have tried hard and failed. Consequently, they have adopted a belief that they can not learn mathematics" (p. 95).

There is general agreement (Kane, Sandretto, & Heath, 2002) from the findings of research into pre-service teachers' beliefs that:

- students enter teacher education programs with pre-existing beliefs based on their experience of school;
- these beliefs are robust and resistant to change;
- these beliefs act as filters to new knowledge, accepting what is compatible with current beliefs; and
- beliefs exist in a tacit or implicit form and are difficult to articulate.

Thus, it is possible to hypothesise that negative beliefs may contribute to negative classroom teaching strategies, which may in turn contribute to negative pupil beliefs, attitudes and performance outcomes. If these pupils then go on to become teachers, a cycle of negativity may be created unless an appropriate intervention breaks the cycle.

Similar findings are reported when attitudes are added to the mix of relationships. The possibility of a cycle of negativity is evident in a study by Davies and Savell (2000) of 53 New Zealand early childhood pre-service teachers who entered their teacher preparation program feeling negative about mathematics, while Grootenboer (2002) reported similar findings for 31 New Zealand pre-service primary teachers. Bobis and Cusworth (1994), in a study of 138 pre-service primary teachers' attitudes toward mathematics, used a questionnaire to measure attitudes and mathematical self-concept. They reported that attitude toward mathematics was greatly influenced by experiences at high school. This was also confirmed by Klein (2004). In a follow up study, Bobis and Cusworth (1995) again reported the difficulty of overcoming "ingrained notions developed during previous school experiences" (p. 109). Negative attitudes may persist beyond university, as Wood (1987) examined American elementary mathematics teachers and stated that "despite the fact that the research does not support the hypothesis that most elementary teachers hate or fear mathematics, it does support the contention that a *significant minority* feels this way" (p. 11). He suggested that the anxious teacher might be a symptom of the lack of a solid knowledge base.

Earlier, Caraway's (1985) data revealed that mathematics competency and achievement were both positively correlated with attitude toward mathematics. This is also true for pre-service teachers, as reported in the study by Rech et al. (1993) who compared the mathematical competencies and attitudes of American pre-service elementary education students against a representative college population, over three years. The results supported Caraway's findings and also showed that the pre-service teachers possessed significantly more negative attitudes toward mathematics than the general college sample.

However, attitudes may not be as robust as beliefs. A study involving both Australian and New Zealand pre-service teachers (Grootenboer & Lowrie, 2002) reported that their affective responses to mathematics were generally more positive in the third year of the program than they were in the first year. Also, the Australian participants were significantly more positive than the New Zealand participants. Research reports a relationship between attitude and classroom teaching. Klein (2004) used poststructuralist analysis on earlier studies to argue that the beliefs and attitudes of pre-service teachers as a result of their school mathematics experiences and the pedagogical practices in their teacher education were obstacles in promoting inquiry based learning and pedagogy in the primary classroom.

White (1998) found that Australian primary teacher beliefs had a significant influence upon their attitudes and intentions to use the calculator in the classroom. Teacher attitudes were also found to have a significant influence upon their intentions to use calculators. Studies of primary school teacher intentions towards the use of group work (White, 1999), and towards the use of worksheets in the classroom (White, 2000), reported similar findings. Other studies have shown that classroom strategies used to teach a subject are influenced by teacher attitudes that, in turn, influence pupil attitudes (Carpenter & Lubinski, 1990). Positive teacher attitudes contribute to the formation of positive pupil attitudes (Relich, Way, & Martin, 1994). Of interest is how tertiary educators produce positive attitudes in their pre-service teachers. Can attitudes be improved without first improving mathematical achievement or beliefs?

Methodology

A total of 83 primary Bachelor of Education pre-service teachers undertaking their first mathematics pedagogy subject at the University of Western Sydney provided responses for this study. The ages of the student teachers ranged from 18 to 53 years, with 40% of them 20 years or less, another 34% between 21 and 30 years inclusive and 26% over 30 years old. This distribution of ages is typical of the University of Western Sydney primary teacher education intakes, with high proportions of 'non-recent school leavers'. All but 12% of the respondents had studied mathematics at the Higher School Certificate level (that is, until the end of high school). The 83 participants were located on two different campuses of the university.

Three surveys were administered during class time at the conclusion of the participants' first mathematics pedagogy subject in 2004. All three surveys were trialled with a smaller sample of pre-service teachers earlier in the year and amended as necessary.

Attitudes to Mathematics and Mathematics Teaching Survey

The attitude survey consisted of 20 items which the respondents were asked to complete on an eight point scale: "Definitely False" (DF), "False" (F), "Mostly

False" (MF), "More False Than True" (MFTT), "More True Than False" (MTTF), "Mostly True" (MT), "True" (T) and Definitely True" (DT). Another response: "Not applicable to me" (NA) was also available. The attitude survey was developed by Relich, Way and Martin (1994) from a composite of subscales derived from Marsh's (1988, 1990) self-concept items, the Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) and the parallel scales for Attitudes to Teaching Mathematics used by Nisbet (1991). The 65-item questionnaire was administered to 345 pre-service teachers from three different teacher education courses in the Sydney region. The responses were subjected to factor analysis, regression analysis and analyses of variance, revealing the two strong subscales of attitude and self-concept that were represented by a set of 12 reliable survey items.

Beliefs about Mathematics, Mathematics Learning and Mathematics Teaching

The belief survey consisted of 18 items to which the participants were asked to respond Disagree, Undecided, or Agree. The survey was developed and used successfully in a number of different contexts (Foong & Perry, 1998; Perry, Howard, & Tracey, 1999; Perry et al., 2002; Perry, Wong, & Howard, 2006). It is based on statements summarising modern approaches to mathematics and its learning and teaching and provides an overview of commonly espoused teacher beliefs.

Mathematical Achievement

The mathematical achievement survey consisted of 23 items which were linked in groups, covering the areas of basic concepts, numeration, basic facts, four operations, order of common fractions, operations with common fractions and decimal fractions, percentages, measurement, order of operations, and word problems. The level of ability required ranged from early primary to lower secondary. The complete survey is given in Appendix A.

Results and Analysis

Attitudes to Mathematics and Mathematics Teaching

All 83 participants completed the attitude survey (alpha reliability was 0.88). A summary of their responses is given in Table 1.

The data from this study show that, in the cohort of pre-service teachers involved, there was an overall trend towards positive attitudes to mathematics and the teaching of mathematics, and a general security or confidence in their abilities. For example, 67% of the pre-service teachers responded at level 5 or above to the item "I am quite good at mathematics". A similar trend appears for the items about the teaching of mathematics. For example, 83% agreed with the statement "I am confident about the methods of teaching mathematics".

Table 1
Responses to attitudes survey (n = 83)

Attitude item number	Percentage of responses								
	0 NA	1 DF	2 F	3 MF	4 MFTT	5 MTTF	6 MT	7 T	8 DT
1. Generally I feel secure about the idea of teaching mathematics.	0	1	2	5	13	27	34	15	4
2. I find many mathematical problems interesting and challenging.	0	2	2	5	13	27	23	18	10
3. Mathematics makes me feel inadequate.	0	10	34	21	10	11	7	8	0
4. I'm not the type of person who could teach mathematics very well.	0	11	33	31	12	15	7	2	0
5. I have always done well in mathematics classes.	0	4	10	10	15	12	25	23	2
6. I do not enjoy having to teach mathematics.	1	17	27	21	15	15	4	2	0
7. I am quite good at mathematics.	0	4	5	6	18	16	37	12	2
8. I have generally done better in mathematics courses than other courses.	0	11	16	4	19	23	15	11	2
9. I'm not sure about what to do when I'm teaching mathematics.	0	7	17	31	16	15	8	6	0
10. Time passes quickly when I'm teaching mathematics in Practice Teaching sessions.	13	0	2	10	7	25	22	17	4
11. I have hesitated to take courses that involve mathematics.	2	12	29	15	8	12	12	5	5
12. I would get a sinking feeling if I came across a hard problem while teaching mathematics at practice teaching.	1	0	23	15	11	22	6	12	11
13. Teaching mathematics doesn't scare me at all.	0	5	16	17	17	13	18	11	4
14. At school, my friends always came to me for help in mathematics.	0	13	19	16	8	19	15	7	2
15. I am confident about the methods of teaching mathematics.	0	0	9	9	17	26	27	13	0
16. I have trouble understanding anything hat is based upon mathematics.	0	15	39	18	15	8	5	1	0
17. It wouldn't bother me to teach a lot of mathematics at school.	0	2	6	11	16	15	23	24	4
18. I never do well on tests that require mathematical reasoning.	0	6	27	23	16	10	10	8	1
19. Of all the subjects, mathematics is the one I worry about most in teaching.	0	13	27	19	7	10	8	12	4
20. If I taught in a team or with a teaching partner, I'd like to have another teacher teaching the mathematics.	0	7	31	15	16	10	7	11	4

Attitude Scale Factors

Before undertaking a factor analysis of the attitude responses, items were recoded so that all items could be scored as positively worded items. With this preparation, two interpretable factors – insecurity and confidence – were determined by applying exploratory principal components factor analysis using a scree plot and the Varimax rotation procedure. The loading of the attitude items onto these factors is shown in Table 2. The two factors account for 55% of the item variance.

Table 2
Item loadings onto two interpretable factors for espoused attitudes

Item number	Insecurity	Confidence
1.	-0.72	0.38
2.	-0.38	0.53
3.	0.57	-0.50
4.	0.76	-0.36
5.	-0.29	0.84
6.	0.75	-0.36
7.	-0.37	0.84
8.	-0.25	0.70
9.	0.65	-0.13
10.	-0.26	0.14
11.	0.25	-0.64
12.	0.53	-0.40
13.	-0.56	0.31
14.	-0.23	0.67
15.	-0.71	0.18
16.	0.42	-0.60
17.	-0.55	0.45
18.	0.50	-0.53
19.	0.67	-0.48
20.	0.59	-0.41

There is a clear factor structure resulting from this analysis and factor scores for insecurity and confidence were calculated for each case.

The identification of the two main factors of insecurity and confidence was strong, with all but three (Items 10, 11, 15) of the 20 survey items clearly loading onto one or the other factor (Table 2). The two identified factors are clearly different, with little interaction between them. This indicates that it is possible for an individual to hold both attitudes simultaneously, thus at times feeling confident about their involvement with mathematics and in other situations feeling insecure.

Beliefs about Mathematics, Mathematics Learning, and Mathematics Teaching

All 83 participants completed the beliefs survey (alpha reliability was 0.58). A summary of their responses is given in Table 3.

Examination of Table 3 reveals a strong tendency in positive responses towards constructivist approaches to mathematics learning and teaching. Despite this tendency, there is evidence of some remaining indecision. See, for example, the strong agreement with constructivist-based statements of Items 6, 13, and 18, and the more evenly distributed beliefs in other constructivist related statements, such as Items 7, 11 and particularly Item 16. Also apparent in Table 3 are some seemingly contradictory beliefs regarding the nature of mathematics. For example, almost all respondents are definite about what mathematics is not about (Item 5), but fewer are sure about what mathematics is about (Items 1, 3, 4, 6).

Table 3
Responses to beliefs survey (n = 83)

	Percentage of responses		
Belief statement number	Disagree	Undecided	Agree
1. Mathematics is computation.	18	31	51
2. Mathematics problems given to students should be quickly solvable in a few steps.	63	24	13
3. Mathematics is the dynamic searching for order and pattern in the learner's environment.	0	26	74
4. Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking.	11	25	64
5. Right answers are much more important in mathematics than the ways in which you get them.	95	4	1

6. Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences.	5	16	80
7. Students are rational decision makers capable of determining for themselves what is right and wrong.	22	40	39
8. Mathematics learning is being able to get the right answers quickly.	90	9	1
9. Periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process.	5	12	83
10. Young students are capable of much higher levels of mathematical thought than has been suggested traditionally.	4	23	74
11. Being able to memorise facts is critical in mathematics learning.	23	41	36
12. Mathematics learning is enhanced by activities which build upon and respect students' experiences.	2	5	93
13. Mathematics learning is enhanced by challenge within a supportive environment.	0	2	98
14. Teachers should provide instructional activities which result in problematic situations for learners.	11	29	60
15. Teachers or the textbook – not the student – are the authorities for what is right or wrong.	70	27	4
16. The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge.	36	28	36
17. Teachers should recognise that what seem like errors and confusions from an adult point of view are students' expressions of their current understanding.	2	14	83
18. Teachers should negotiate social norms with the students in order to develop a co-operative learning environment in which students can construct their knowledge.	1	15	84

Five interpretable factors – student respect, computation, transmission, development, and decision-making – were determined by applying exploratory principal components factor analysis using a scree plot and the Varimax rotation procedure. The loading of the beliefs items onto these factors is shown in Table 4. The five factors account for 38% of the item variance.

Table 4
Item loadings onto five interpretable factors for espoused beliefs

Item number	Student respect	Computation making	Transmission	Development	Decision
1.	.09	.45	-.09	-.02	-.35
2.	-.17	.83	.19	-.03	.24
3.	.06	.14	-.14	.42	-.03
5.	-.18	.26	-.08	-.48	.17
6.	.43	-.02	-.05	.05	.05
7.	.09	.03	.06	-.11	.54
11.	-.05	-.04	.37	-.03	-.44
12.	.48	-.21	-.16	.11	.17
13.	.85	.02	.14	.13	-.05
14.	.06	-.12	.04	.45	-.16
15.	-.01	-.07	.75	.00	.02
16.	-.03	.15	.30	-.03	-.01
17.	.08	.05	-.05	.48	.25
18.	.39	.18	-.35	.19	-.05

Mathematical Achievement

Seventy-eight of the pre-service teachers completed the 23-item mathematics achievement test (Appendix A) (alpha reliability was 0.75). The test was set at no higher than an early secondary school level of basic number skills. Responses were allocated a mark if the answer was correct and no marks for an incorrect answer. Total marks ranged from 10 to 21 with mean 16.09 and standard deviation 3.21. Table 5 shows the percentage of pre-service teachers achieving each score. Overall, achievement on this test was poor, with only 5% of the participants scoring more than 90%, and 13% of them scoring less than 50%.

Table 5
Total mathematics achievement scores (n = 78)

Score	10	11	12	13	14	15	16	17	18	19	20	21
Percentage of cohort	9	4	4	8	5	8	8	18	8	18	6	5

The alpha reliability for this achievement survey was 0.75. When the test items are grouped into categories with the percentages of pre-service teachers giving correct responses (Table 6), it can be seen that the most troublesome topic was that of decimal fractions (26%). The pre-service teachers also exhibited low proficiency in the other categories involving fractions (order 61.3%, operations 63.5%, percentages 66.7%).

Table 6
Number and percentages of correct responses for each category of items

Category	No. of Items in each Category (Items)	No. of Correct Responses	Percentage of Correct Responses
Basic concepts, Numeration	3 (5,6,7)	155	65.8 (*98.7)
Basic Facts	3 (1,2,3)	154	66.2 (*98.7)
Four operations	5 (8-12)	389	83.1
Order of Common Fractions	1 (13)	48	61.3
Operations with Common Fractions	2 (14,15)	99	63.5
Decimal Fractions	1 (19)	21	26.9
Percentages	3 (16,17,18)	156	66.7
Measurement	2 (22,23)	121	76.6
Order of Operations	1 (20)	58	74.4
Word problems	1 (21)	48	61.5

*Percentage of non-responses to items 3 and 7 are not included.

A more detailed analysis of the mathematics knowledge results in terms of the weaknesses of understanding of specific mathematical concepts shown by many of the pre-service teachers can be found in Southwell and Penglase (2005).

Relationships Between the Surveys

In earlier papers, the authors have reported on a number of aspects of these data. Only a brief summary of their findings is given here.

Beliefs and Achievement

Perry et al. (2005) have considered relationships between the pre-service teachers' responses on the beliefs and mathematical knowledge surveys. They have summarised their major findings in the following way:

> Though the connections between beliefs and achievement were not striking, of interest is the consistency of the negative correlation of beliefs about the nature of mathematics (Items 2 & 5) to achievement test scores. That is, the stronger the belief in the importance of computation and correct answers, the lower the achievement performance. On the other hand, Item 13 was positively correlated to higher scores in the achievement test. Item 13 had a high loading in the factor of 'Student Respect', and students who rated the key items (6, 12, 13, 18) highly showed a positive tendency towards achievement. It is not possible to determine the direction of any cause and effect in these relationships, but perhaps there is a self-esteem element at work. (p. 631)

Attitudes and Achievement

Southwell et al. (2006) have considered links between attitudes and mathematical knowledge as displayed in the two surveys. They summarised their findings in the following way:

> This study highlights a number of important results that provide further information concerning the links between achievement in mathematics and attitudes towards mathematics. ... It has identified two main factors of insecurity and confidence contributing to one's attitudes towards mathematics and teaching mathematics. In general, the study has indicated an overall trend towards positive attitudes towards mathematics and teaching mathematics. Despite this, the students' results on the mathematics achievement test were low, thus supporting other researchers' (Amarto & Watson, 2003; Chick, 2002; Morris, 2001) findings. These low mathematics scores may seem contradictory in the light of more positive attitudes. They indicate, however, that students' espoused confidence in their mathematical ability does not necessarily ensure high achievement. To counteract this finding, the level of confidence in teaching mathematics is a better predictor of mathematical achievement than confidence in one's own ability. This may point to the relative stability of attitudes towards one's own mathematical ability as a student compared to attitudes about teaching.
>
> The clear connection between the attitudes and the achievement scales was generally as expected. The strength of the connection between the two suggests that, among other things, mathematics teacher educators need to enable pre-service teachers to have success in their mathematics while, at the same time, providing methods and models of good pedagogical practice. (pp. 11-12).

Beliefs and Attitudes

The earlier discussion on difficulties in defining beliefs and attitudes in mathematics education might lead one to speculate that they should be quite different constructs and that there may be little expectation of relationships between beliefs and attitudes. This is certainly the case with the current data. In the previous studies (Perry et al., 2005; Southwell et al., 2006), factor analysis was used to develop a factor stucture of five factors for the beliefs scale and a much more robust two factors for the attitudes survey. Further, it was seen that the two-factor analysis for the entire attitude scale remained pertinent when the 11 items referring particularly to teaching mathematics and the 9 items referring to oneself as a mathematics learner were treated as two separate subscales. In this study, when Pearson moment correlations were calculated for each of the attitude factors (both complete and the two subscales) against the five beliefs factors, only one statistically significant correlation was determined, relating the insecurity about teaching mathematics factor from the attitudes survey and the transmission factor from the beliefs survey (r=0.26, p<0.05). This suggests a plausible relationship between being insecure in one's mathematics teaching and believing that one way to resolve this issue is through teaching mathematics in a transmission mode, a finding also noted in an earlier study by one of the present authors (Perry et al., 1999).

While there are a number of statistically significant correlations among individual items on the attitudes and beliefs survey, these are not recorded here as they are not strong and do not seem to have a great deal of educational significance.

Conclusions and Implications

Each of the instruments was constructed for different purposes originally, and, while they ostensibly could be regarded as capable of indicating relationships between the three constructs under consideration, the results seem to show a possible dysfunction in terms of what might have been expected from this study. To more adequately test the relationship between beliefs, attitudes and mathematical achievement, more connected instruments may need to be devised. In particular, a more comprehensive instrument in mathematical achievement is needed.

The analysis above, contrary to expectations, reveals a lack of relationship between beliefs and attitudes with the only statistically significant relationship between insecurity about teaching mathematics in the attitudes scale and the transmission factor in the beliefs scale. Also, the data from the attitudes scale indicate that a negative attitude regarding the nature of mathematics does not preclude a positive attitude to achievement in mathematics. At different times an individual can feel insecure about one aspect of mathematics and confident about their ability to handle mathematics in the classroom. This means that a student could be keen about doing mathematics but not have the necessary background to succeed. The reverse situations could also apply. There could be several reasons for this ambivalent result. Having recognised a lack of understanding in mathematics, students may well decide to work much harder and consequently do better. Then, also, if participants consider themselves inept at mathematics, a more concentrated attempt to improve might occur.

Despite the limitations of this study, it indicates for the participants that, while attitudes are important, they are not sufficient to predict their success in teaching. Positive attitudes are necessary, but not sufficient. Even if pre-service teachers have positive attitudes, they need to also know their mathematical content. Pre-service mathematics education courses, then, must deal with attitudes and beliefs as well as pedagogical content knowledge. Specific attention to the nature of mathematics is important. This is a critical implication of this study and supports the recommendations of the Australian Association of Mathematics Teachers statement on *the Standards for Excellence in Teaching Mathematics in Australian Schools* (2002).

In New South Wales, the Department of Education and Training requires that for teachers to be accredited to teach in public schools, they have to have completed two units of mathematics at the Higher School Certificate level. Almost all the participants in this study have complied with this requirement so that particular aspect does not appear to have any influence on the results the participants achieved. In terms of the data in this study, the level of confidence in teaching mathematics may be a better predictor of success in mathematical achievement. This result calls into question the necessity for the requirement imposed by the Department or the applicability of the Higher School Certificate course for primary teacher education. The required level of mathematical achievement must be reached but perhaps this is best accomplished in terms of well constructed pedagogical units in teacher education programs.

The authors acknowledge that this study has been confirmatory rather than revolutionary. It has, however, yielded some interesting results that could well be explored further. The implications for teacher education courses in primary school mathematics pedagogy are concerning but also challenging. A more structured and longitudinal study in terms of the specific attitudinal and belief factors indicated by this study is needed to further investigate their relationship to achievement in mathematical content.

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Appendix A: Mathematical Knowledge of Primary Teacher Education Students-Number Survey

No calculators allowed.

1. Write two different numbers that add up to 19.
   Write another two numbers that add up to 19.
   How many such pairs of numbers are there?
2. There are 18 counters in view and you are told that under a piece of paper, there are some more. Altogether, there are 64 counters. How many are under the piece of paper?
3. Put the numbers: 4 680, 8 640, 6 480, 6 840 and 4 860 into order from smallest to largest.
4. Write this number in words: 6 745 901.
5. Expand 4 609 234 using powers of 10.
6. Calculate 456 + 789 (Show all your working.)
7. Calculate 1 327 – 678 (Show all your working.)
8. Calculate 47 x 25 (Show all your working.)
9. Calculate 47 x 25 using a different method than above. (Show all your working.)
10. Calculate 378 divided by 7 (Show all your working.)
11. Put these fractions in order from smallest to largest: $\frac{5}{8}; \frac{2}{3}; \frac{4}{5}$
12. Find $\frac{5}{8} - \frac{2}{5} =$
13. Find $\frac{4}{5} + \frac{2}{3} =$
14. Find the cost of a $1 600 television if it was reduced by 15%.
15. Convert 17% to a decimal fraction.
16. Convert $\frac{3}{5}$ to a percentage.
17. Calculate 14.83 x 0.06
18. Calculate (5 x 56) + (2 x 17) – (42 -13) =
19. Solve this problem. (Show all working.)
    Smithtown School hired buses to take its students to the cricket ground. If there are 1 023 students and 63 can fit into each bus, how many buses were needed?
20. Convert the following measurements to the units indicated:
    a) 6.23 km = m
    b) 5.987 L = mL